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ABSTRACT

This review of research on the effectiveness of adding questions to text materials to improve learning and the research on feedback posits that there is a connection between the findings in these two areas that can be viewed from an information processing perspective. A model of information processing taken from Gagne is used to organize the question and feedback effects. This model postulates features such as sensory registers, short-term memory, long-term memory, and an executive control mechanism. In addition to these internal processes, nine external events that can be made to influence the processes of learning: (1) gaining attention; (2) informing the learner of the objective; (3) stimulating recall of prerequisite learning; (4) presenting the stimulus material; (5) providing learning guidance; (6) eliciting the performance; (7) providing feedback about performance correctness; (8) assessing the performance; and (9) enhancing retention and transfer. It is argued that questions and feedback may serve different functions according to which event of instruction--that is, which internal process--they are being used to enhance. The various roles that questions can serve in the learning process are discussed in the context of each of the nine external events, and it is postulated that feedback also serves different purposes at different stages in learning. Some examples of how the role of the question might determine the appropriate type of feedback are provided in a table. It is suggested that, in order to determine the "best" type of feedback in a given situation, one has to take into consideration the purpose of the feedback as well as the type of question, the stage of information processing, and conditions within the learner. (37 references) (BBM)

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Title:

Feedback, Questions and Information Processing -- Pulling it All Together

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Feedback, Questions and Information Processing -- Pulling it all together.**
1992 AECT presentation
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Frase (1970), Rothkoph (1970), Bibiscos (1967), Anderson (1970, 1975) and others have produced a large volume of research that looks at the effect of adding questions (adjunct questions) to text materials to improve learning. In general their findings reflect that prequestions may serve an orienting function if they are placed at the beginning of a text passage, facilitating selective attention. The researchers reach this conclusion because the subjects in the research tend to remember information related to the questions than other "incidental" information in the text. However, there is a fair amount of research that finds no facilitating effect for inserted prequestions. One reason, perhaps, is that the learner does not remember the prequestions long enough for them to be of any use in the text. Another possible reason is that the questions cue the learner as to what the text is about but they are just not interested enough in the content to devote the effort needed to learning it.

Likewise the effect of questions following the text and questions inserted in the text have been studied with contradictory results. In general it has been found that questions placed after text materials facilitates long-term recall of information about the text. Subjects given prequestions seem to learn more "incidental" material than those given postquestions, and they seem to do better on inferential questions as opposed to detail questions. The researchers hypothesize that post-questions serve a rehearsal function that facilitates recall.

Research on feedback has looked at many different independent variables including type of feedback, timing of feedback, placement of feedback, and the learner's degree of confidence in responding. Dependent variables include the number of questions answered correctly on a post-test that were missed in the material, the number of correct in the material missed on the post-test, and the response patterns correlated with response certainty. Most of the research in this area is limited to verbal learning tasks, and the few related to concept learning tasks show no significant differences. The findings, in general show feedback to be superior to no feedback, but show very few differences that can be attributed to the type of feedback. Kulhavy (1977) reports finding what he calls a delayed retention effect, which appears if the feedback is massed at the end of the instruction rather than given immediately after the response. He hypothesizes that immediate feedback activates an interference effect caused by a discrepancy between the student's answer and the correct answer. This interference is reduced or eliminated through the use of delayed feedback, however, it is moderated by other variables like response certainty.

How is the research on questions and the research on feedback related? There is virtually no reference of one set of literature in the other yet both may looking at similar phenomenon. We believe there is a connection between question research and feedback research findings that can be viewed from an information processing perspective.

Atkinson and Shiffrin (1968) , Gagné (1985) , and Kumar (1971) have identified "stages" of information processing. Research on learning has typically investigated the effects of instructional intervention on one or more of these stages. For example, research on adjunct questions has focused on the stage Kumar refers to as selective attention, whereas pre-instructional strategies such as providing learning objectives seems to focus on stimulus perception through the arousal of expectations. Considering that questions may serve different roles in instruction, depending upon the stage of information processing they impact, it is reasonable to expect that feedback might serve different purposes, as well.

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** *This paper is abstracted from a chapter in Interactive Instruction and Feedback, edited by J. V. Dempsey and G. Sales, Educational Technology Publications, in press.*

It is helpful to identify a model of information processing to use in the organization of question and feedback effects. The model we use is taken from Gagné (1985) which is based on Atkinson and Shiffrin's (1968) model This model postulates features such as sensory registers, short-term memory, long-term memory and an executive control mechanism.

Information processing is set into effect when something from the learner's environment stimulates the learner and activates receptors which transmit information to the central nervous system. After a brief registration in one of the sensory registers, it is transformed into recognizable patterns put into short-term memory (STM). This transformation is referred to as selective perception. Storage in the STM has a relatively brief duration, usually less than 20 seconds, unless some sort of rehearsal takes place. Additionally, STM is limited in its capacity: only a few separate items can be kept in STM at one time. In order that information can be remembered for longer periods and in larger quantities, it must be semantically encoded to a form that will go into long-term memory (LTM). Both information from short-term and long-term memory may be passed to a response generator and is transformed into some sort of action. The message serves to activate effectors which result in a performance that can be observed to occur in the learner's environment

Although these processes are internal to the learner, there are external events -- events outside the learner -- that can be made to influence the processes of learning. The nine events include:

1. Gaining attention,
2. Informing learner of the objective,
3. Stimulating recall of prerequisite learning,
4. Presenting the stimulus material,
5. Providing learning guidance,
6. Eliciting the performance,
7. Providing feedback about performance correctness,
8. Assessing the performance, and
9. Enhancing retention and transfer.

It is to these nine events of instruction that we will address the issue of questions and any ensuing feedback. It is our contention that questions and feedback may serve different functions according to which event of instruction -- that is, to which internal process -- they are being used to enhance.

Event 1: Gain Attention. Attention usually involves the two processes of (1) orientation of the receptors toward the stimulus and (2) the encoding of the stimulus (Anderson, 1970), only the first of these two processes relates to this first stage of information-processing. Although the process of gaining attention is thought of as an initial event, control of attention within the lesson has been found to be important when students are bored, tired, or under pressure to work quickly, as well (cited in Anderson, 1970). Questions presented as a stimulus for attention arousal will not guarantee that what is to follow will be learned. Unless this attention arousal does occur, however, there will not be adequate reception of the stimuli by the receptors to allow for the other processes to occur. Feedback for attention questions is probably rhetorical, if given at all. It may be desirable to allow students to express answers without confirmation of correctness if the object is to create cognitive dissonance or information search, for example, starting a class by asking, "Why are more men bald than women?" Attention questions might increase uncertainty about what the learner already knows, creating epistemic curiosity. In this case, there is no need for feedback because the purpose of the event is to have the student seek the answer to the question in the subsequent instruction. Table 1 below shows how other events might be treated with regard to feedback.

Table 1.
Recommendations for the use of questions and feedback related to stages of information processing

Function of the question	Function and type of feedback
1. Gaining Attention	1. Arousal, Create Cognitive dissonance. Open ended questions with no feedback.
2. Inform the learner of the objective.	2. Create an expectancy for performance. Rhetorical questions and didactic answers could be used to inform the student of the objectives.
3. Stimulate the recall of prerequisite learning	3. Bring related knowledge into short-term memory and confirm present knowledge. Questions eliciting analogies with right-wrong or conditional feedback could be used to test the understanding of prerequisites. Pretests may serve the same function (with or without feedback).
4. Present the stimulus material	4. Socratic dialog to have the student deduce what information is needed. Feedback takes the form of confirmation of responses, and probing questions to guide inquiry
5. Provide learning guidance	5. Questions provide for modeling component parts of the skill being learned. Feedback should show correct answers for analysis by the student.
6. Elicit the performance	6. Questions recall learned skill or components of the learned skill to test for misunderstanding. Feedback should be remedial, directed at the misunderstanding if possib.
7. Provide feedback	7. Feedback should be chosen to fit the purpose that the question is serving in the instructional process. It is possible that the type of feedback should vary with the learners performance and confidence. Give knowledge of correctness and remediation for incorrect answers.
8. Assess performance	8. The purpose is to inform the student of progress toward mastery. Feedback should inform the student of the adequacy of his or her performance.
9. Enhance retention and transfer	9. Provide for spaced practice of the newly learned skill in an authentic situation. Immediate feedback as to correctness would seem most appropriate.

Event 2: Informing the Learner of Objectives. Questions may serve the same purpose as behavioral objectives when they they activate a process of executive control. This is supported by the notion that schemas control perception and that activating these schemas through questions can affect selective perception (West, Farmer, and Wolff, 1991).

Sagerman and Meyer (1987) found a learning effect that resulted from the type of adjunct questions presented after a passage of text. Learners given verbatim questions (i.e., questions in which the learner was asked to recognize a sentence presented in the text) seemed to focus on verbatim details for subsequent passages. Learners who received conceptual questions (i.e., questions that require inferring an answer from information in the text), by contrast, did better on posttest conceptual questions than the verbatim group. This effect, which has been referred to as forward transfer, or specific forward effect (Rickards, 1979), is similar to the effect found by researchers of performance objectives. Faw and Waller's (1976) review of the objectives literature found that (specific) objectives focus attention and improve performance on test items related to those objectives but depress performance on incidental items. When combined with Rickards' (1979) findings, it may be that the type of objective (detailed or general) might affect subsequent processing of the passage more than the content, since it is unlikely that the learner will keep all the objectives in mind while reading.

Event 3: Stimulate the Recall of Prerequisite Learning. After the sensory registers have recorded the information, selective perception takes place for storage in short-term memory. The function of questions during this stage would be to aid the student in recalling prerequisites into short-term memory in order to enable integration of previously learned information with new information or skills.

What is learned, in most instructional situations, depends a great deal on the activities of the student. Rothkopf (1970) calls behaviors that give birth to learning "mathemagenic" behaviors. Similarly, Kumar (1971) points out that which information that is transferred to short-term memory or long-term memory depends on the learner and a set of processes under the learner's control. These processes, termed "control processes" (Atkinson & Shiffrin, 1968) include the process of selective attention. The learner can selectively extract information according to his or her perceived importance of the information. This results in a reduction of the information present at initial registration, since only selected aspects are focused upon (Kumar, 1971).

Event 4: Presenting the Stimulus Material. Questions may be used to enhance the presentation of the insructional stimulus. Short-term memory (STM) is limited both in duration and capacity. It is generally recognized that storage of information lasts no more than 20 seconds (usually less), and capacity consists of about seven units of information at a time (Miller, 1956; Kumar, 1971). However, the duration of information in STM can be increased through rehearsal, and capacity can be increased by chunking.

Questions at this stage can serve to maintain and renew the items stored in short-term memory. They may also aid learners in organizing information into manageable chunks or propositions. Feedback would serve to confirm the adequacy of rehearsal strategies or the propositions and provide reinforcement. Prompts or cues might be used to aid in the process of chaining and linking various sequential chunks together (Anderson, 1970). These hints could then be faded as the student becomes more proficient in the task. Prompts help the learner respond correctly to a question by focusing attention on relevant stimuli (W. Wager & S. Wager, 1985). Two recognized types of prompts include (1) formal prompts, such as spaced blanks in questions which denote the length of the answer, and (2) thematic, contextual, or grammatical cues. Questions with prompts probably work by

decreasing cognitive load during early stages of learning, and aid encoding by providing for rehearsal and repetition.

Event 5: Provide Learning Guidance. Information which has successfully been maintained in short-term memory must be semantically encoded for storage in long-term memory. Questions may be used at this stage to encourage learners to integrate new knowledge into existing cognitive structures. Andre (1979) distinguishes two distinct memory stores within long-term memory: (1) episodic memory, which contains a record of events encountered and (2) semantic memory, which contains abstracted or generalized knowledge such as concepts, principles, rules, and skills that are broader than specific episodes. He suggests that this knowledge is represented as schema in semantic memory and that semantic memory consists of a network of interrelated schema. He also estimates that higher-level questions influence the nature of the representation that is formed when learners acquire new information in semantic memory. Kumar (1971) also suggests that encoding may be the same thing as schematizing. The addition of new knowledge to existing memory schemas is referred to as accretion, the most common mode of learning (Norman, 1982).

Questions may reduce the variance in processing information, thereby enabling or facilitating rapid encoding (Miller, 1956). For example, in a rote memorization task of memorizing a list of words, the way in which a question is constructed can aid in more rapid encoding of the task. Consider the following list of words:

APPLE	SHIRT
CHAIR	CARROT
PANTS	ORANGE
ONION	PLATE
CHERRY	SHOES
TABLE	POTATO

To successfully memorize the list in 30 seconds may prove somewhat difficult. However if a student is asked to memorize the words as presented in a new list – one in which the words have been put into sets which allow for them to be remembered according to some sort of prior schema – the words are much easier to successfully memorize in the allotted 30 seconds:

Categories

SHIRT	CARROT
PANTS	ONION
SHOES	POTATO
TABLE	APPLE
CHAIR	ORANGE
PLATE	CHERRY

However, the group given the first list with the question, "What four categories of things can the following list be sorted into?" should be able to produce the second list for themselves. Reigeluth (1983) describes this as strategy activation. If questions cause a forward transfer effect, as described by Sagerman and Meyer (1987), these types of questions might build a stronger use of strategies in future learning, at least for students who are able to apply the strategy.

Feedback given in response to questions which serve to aid in semantic encoding can validate the integration of new information with pre-existing knowledge or it may serve to equalize question links between existing structures and new structures even further. Feedback also may serve as learning guidance through the demonstration of processes. Elaboration in feedback provides the opportunity for additional information to be stored.

In fact, elaborations provide redundancy in the memory structure which can act as a safeguard against forgetting and as an aid in fast retrieval (Reder, 1980).

Event 6: Elicit Performance. Questions can be used to activate response organization. According to Bartlett (cited in Kumar, 1971), "a schema is an active organization of past experiences" (p. 403). Although schemas may be different, they are still interconnected by common factors in an organized way. The process of reconstruction activates a number of relevant schemas to recreate the event (Kumar, 1971). Questions can act to help in this process of reconstruction by cueing these relevant schemas.

Post-questions act as confirmation for important mathemagenic behaviors, maintaining appropriate responses on succeeding portions of text (Frase, 1970). Questions can test for understanding or misunderstanding. Questions can also act to reinforce learning behaviors. Feedback acts to remediate misunderstanding and to provide spaced reinforcement.

Hamaker (1986) suggests that students receiving feedback to adjunct questions may adopt a passive attitude toward the questions because they know the correct answer will eventually be presented. This would imply that feedback would limit the amount of information search engaged in by a student and lead to a lower level of incidental learning.

Event 7: Provide Feedback. When a response is generated, the learner attempts to confirm the correctness or appropriateness of the response. Feedback serves to provide reinforcement and corrective information to the student which in turn works to provide cues for future performance. Feedback can address whether or not the question was correctly interpreted and whether or not the answer was adequate. Probably the most important role of feedback at this stage is to correct misunderstandings.

Event 8: Assess Performance. Performance via a posttest or retention test is probably the most common way of using questions. Assessing whether or not the task can be performed gives the opportunity for reinforcement and/or validation through variations in context. Feedback confirms that the skill has been generalized to a range of situations.

Event 9: Enhance Retention and Transfer. Knowledge transfer, at the most general level, involves change in the performance of a task as a result of the prior performance of a different task. The difference between "transfer" and "learning" is that in the case of transfer, the two tasks are said to be "different." In transfer paradigms, the "different" task is usually selected to be novel to the student (Gick & Holyoak, 1987). The encoding of a training task will aid subsequent transfer to the extent that the learner has acquired rules that will be applicable to a range of different tasks with "structural commonalties." According to Gick and Holyoak (1987), "if the transfer task evokes similar goals and processing mechanisms, or has salient surface resemblances to the training task, these common components then serve as the basis for retrieval of the acquired knowledge in the transfer context" (p. 40).

One important influence cited as affecting the encoding of the training task is direct feedback about performance levels (Gick & Holyoak, 1987). Feedback can provide guidance and cues as to which rule to apply in certain transfer problems. Similarly, questions which invoke certain commonalties to be recognized and appropriately corresponding rules to be applied can serve as a vehicle for transfer.

Summary

Questions and Feedback are inextricably related. Recently the process-product paradigm research on questions was compared to a sociolinguistic perspective (Carlson, 1991). Carlson argues that the meaning of questions is dependent upon their context in discourse, and that the content of questions cannot be ignored. Some of Carlson's criticisms of research on classroom questions seem pertinent also for research on feedback. Feedback is always related to a response generated by a question. In this sense, the meaning of feedback is dependent upon its context in the instruction. Feedback effectiveness may also be dependent upon certain learner variables, such as the learner's confidence in his or her answer. But these personal factors influencing feedback's effectiveness may vary according to the type of learning task involved (see Mory, 1991) and may very well have fluctuating influences within each stage of information-processing, as well.

In this paper, we have attempted to show how questions serve a variety of roles in the learning process, and so it is reasonable to postulate that feedback also serves different purposes at different stages in learning. Table 1 provides some examples of how the role of the question might determine the appropriate type of feedback. It seems unlikely that we will find any universal agreement on the "best" type of feedback. One has to ask "Feedback for what?", and take into consideration the type of question, the stage of information processing, and conditions within the learner to arrive at an answer.

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